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Analysis of the References from the Guide to the Systems Engineering Body of Knowledge (SEBoK)

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Abstract

Version 1.0 of the Guide to the Systems Engineering Body of Knowledge (SEBoK) was released in September 2012. The SEBoK contained over 1000 articles and almost 700 books as references. 224 of the references were cited as primary references. This paper disaggregates the references by several dimensions. Interesting insights include the most cited references; topics where references are sparse, indicating immaturity of the field; the longitudinal distribution of references; organizations with the most authors cited; and the most active research topics.

Keywords: Systems Engineering; Body of Knowledge; Survey of literature

1. Introduction

The Guide to the Systems Engineering Body of Knowledge (SEBoK) [1] summarizes the literature about systems engineering. This paper describes the SEBoK, and analyzes the references cited in the SEBoK. Section one describes the genesis of the SEBoK. Section two describes the methods employed in this paper, and some caveats. Section three provides a Pareto description of the primary references. Section four discusses topics with the most and fewest references. Section five presents a longitudinal analysis of aspects of the SEBoK. Section six presents the affiliation of authors cited by the SEBoK. Section seven presents some initial usage data on the SEBoK. Section eight concludes with some comments.

1.1. BKCASE Project

In September 2009, the Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE™) project was established with primary sponsorship by the U.S. Department of Defense (DoD) through the Systems Engineering Research Center (SERC). It was a university-led partnership between Stevens Institute of Technology, Hoboken, NJ and Naval Postgraduate School, Monterey, CA, with support from various other universities,

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14. ABSTRACT

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organizations, government agencies, and professional societies. The objective of the BKCASE project was to create and deliver two products: (1) the Guide to the Systems Engineering Body of Knowledge (SEBoK) by September 2012 and (2) the Graduate Reference Curriculum for Systems Engineering (GRCSE) by December 2012. Both these products are intended for worldwide use, available for public use at no cost. At the time of writing this paper, version 1.0 of SEBoK had been released on September 14, 2012 [1] and version 1.0 of GRCSE was on track for release on December 15, 2012.

1.2. The SEBoK

The SEBoK is a major, peer-reviewed addition to the systems engineering literature. It consists of 7 parts broken into 26 knowledge areas, with 113 full length articles on topics. There are 5 use cases, 7 case studies, and 6 vignettes to illustrate the contents. The glossary has 364 entries, and there are 224 primary references. The full set of references includes over 1000 articles and 700 books, written by over 2000 different authors. It is over 850 pages long. The project took three years.

The Office of the Secretary of Defense was the primary sponsor. Partners in the project included the International Council on Systems Engineering, the Institute of Electrical and Electronic Engineer Computer Society, the Institute of Electrical and Electronic Engineer Systems Council, the Association for Computing Machinery, the Institute for Industrial Engineers, and the National Defense Industrial Association.

The SEBoK author team includes 70 contributors from six continents. Comments from several hundred reviewers were submitted, and each comment was addressed, logged, and the response published.

The SEBoK was published in a Wiki format for ease of updating and for community participation in its maintenance.

2. Methods

Students supporting the primary author constructed a database in the summer of 2012 of every reference in the SEBoK. Queries of that database provide some of the data in this paper. Other data was assembled by use of the organic search capabilities in the Wiki hosting the SEBoK.

A few references were added during final editing of the SEBoK, and after the construction of the database. Accordingly, some of the data here may be slightly inexact. The authors claim that this possible imprecision does not detract from the main points below.

3. Primary references

Some 224 of the references in the SEBoK were designated as “Primary References.” That meant a reference was key to understanding one or more topics, and was recommended for reading. Some of the primary references were more heavily cited than others. Table 1 gives the number of topics in the SEBoK that list a given primary reference, in descending order, for those cited in six or more topics.

Table 1: Number of Topics citing a Primary Reference.

Primary Reference	Number of topics citing
INCOSE Handbook [2]	40
ISO 15288 [3]	25
Systems Engineering and Analysis [4]	15
A Journey Through the Systems Landscape [5]	12
Systems Theory, Systems Practice [6]	12
Managing and Leading Software Projects [7]	11
NASA Systems Engineering Handbook [8]	11

General Systems Theory: Foundations, Development, Applications [9]	11
A Guide to the Project Management Body of Knowledge [10]	10
Visualizing Project Management [11]	9
Defense Acquisition Guidebook [12]	9
Software Engineering Body of Knowledge [13]	9
A Case for Service Systems Engineering [14]	7
ANSI/EAC 632 [15]	7
INCOSE SE Vision 2020 [16]	6
Essentials of Project and Systems Engineering Management [17]	6
Service Systems Engineering and Management [18]	6

Table one indicates that the INCOSE Handbook and ISO/IEC 15288 are the most heavily internally cited SEBoK primary references, which is not surprising. The text by Blanchard and Fabrycky [4] is third. Four of the top seventeen references are on project management. Five are standards or handbooks. Three are works on systems science. Sixteen of the seventeen are books; only one of the top primary references is an article. This paucity of journal articles likely reflects the definition of primary reference.

4. Topics and references

Each of the 113 topics had a number of references. Not counting Part 1, which was primarily administrative, and part 7, which was implementation examples, the authors examined the distribution of the number of citations per article. Parts 2 through 5 average about 20 references per article; part 6 has about 10 references per article. Figure 1 shows the distribution of counts.

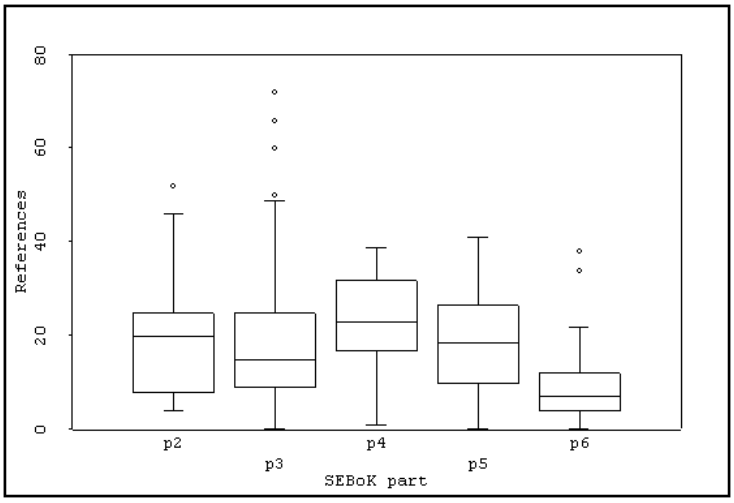

Figure 1: Boxplot of the number of references in each topic, by Part. Part six has significantly fewer references than the other parts.

Articles with relatively fewer references include:

- System fundamentals (5)
- Why model (4)
- Analysing and selecting a solution (4)
- Implementing and developing a system solution (5)
- Deploying, using and sustaining systems to solve problems (5)
- Life cycle characteristics (4)

- System deployment (6)
- Operation of a System (6)
- Systems maintenance (6)
- Information management (6)
- Capability engineering (4)
- The nature of software (7)
- Systems engineering and project management (3)
- Relationships between systems engineering and project management (5)
- The influence of project structure and governance on systems engineering and project management relationships (4)
- Integration of specialty engineering (2)
- System assurance (6)
- Manufacturability and producibility (5)

Fewer references can indicate immaturity of the topic area, although in some cases it can reflect variability between the authors of the topics. The data indicates that the literature on the interface of systems engineering with other supporting disciplines is thin.

Subsequent revisions of the SEBoK will concentrate on expanding the reference sets for those topics that currently have few references. Community recommendations for references are accepted on each topic page by use of the DISQUS comment feature.

Some topics had a relatively richer set of references. They include:

- Patterns of systems thinking (52)
- System life cycle process models: Vee (50)
- System life cycle process models: Iterative (72)
- Service life extension (60)

The more heavily referenced topics are likely partially due to the enthusiasm of the topic authors.

5. Some longitudinal data

The primary references that were books were sorted by the year written, and then plotted in Figure 2, which shows that most of the primary references texts were written in the last ten years.

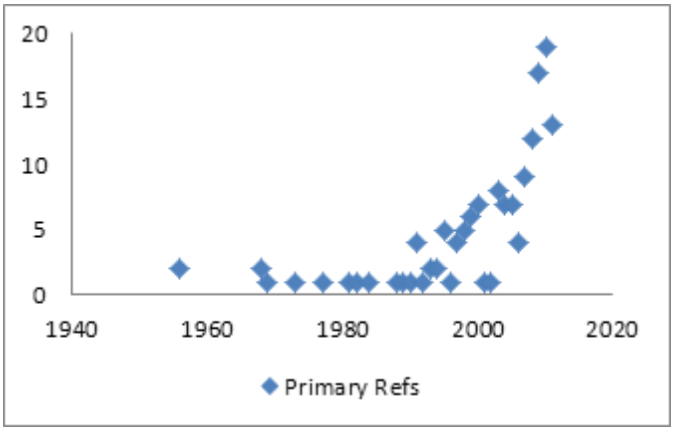

Figure 2: Primary references by year written.

This is consistent with the emergence of systems engineering as a discipline in the last two decades.

6. Affiliations

Over 2000 authors are cited in the SEBoK. The affiliation of about 80% of the authors is known; some sources do not list the affiliation of their authros. Table 2 shows institutions with ten or more authors, where known, cited in the SEBoK. This table gives an insight into the impact of those institutions on the field of systems engineering.

Table 2: Number of authors affiliated with institutions

Institution	Number of authors
Massachusetts Institute of Technology	50
Carnegie Mellon University	45
Stevens Institute of Technology	38
Harvard University	25
University of Southern California	20
California Institute of Technology	19
Naval Postgraduate School	17
MITRE	17
IBM	16
Air Force Institute of Technology	15
University of Michigan	15
Idaho National Laboratory	14
Loughborough University	13
UC Berkeley	12
Keio University	11
University of Virginia	11
Georgia Institute of Technology	10
George Mason University	10

7. SEBoK usage

Patterns of viewing for the SEBoK are still immature as of the writing of this article, since the Wiki has only been posted for 3 weeks. However, some trends are apparent. The main splash page has been viewed the most, by an order of magnitude. The next most popular page is the download page, which has been viewed 2700 times. If readers only use the PDF version, their usage statistics will not be recovered.

Table 3 presents the page views of the administrative and content pages of the SEBoK. These give an insight into the impact of the various topics of the SEBoK, and where the community is seeking the most information.

Table 3: Viewing data for the most viewed pages of the SEBoK.

Page name	Views (thousands)	Admin or content
Main splash page	20.1	Admin
Download the SEBoK	2.7	Admin
Systems	1.9	Content
SEBoK 1.0 Introduction	1.7	Admin
Systems Engineering and Management	1.3	Content
Table of contents	1.0	Admin
Acknowledgements	1.0	Admin
Applications of Systems Engineering	.8	Content

How to read the SEBoK	.8	Admin
Enabling Systems Engineering	.7	Content
Life Cycle Models	.7	Content
Systems Engineering Implementation Examples	.6	Content
Systems thinking	.6	Content
Note to Community	.6	Admin
Related disciplines	.6	Content
Scope of the SEBoK	.6	Admin
Enterprise Systems Engineering	.6	Content
What is a System	.5	Content
Systems Engineering Overview	.5	Content
System Fundamentals	.5	Content
System Definition	.5	Content
Systems and Software Engineering	.5	Content
Representing Systems with Models	.5	Content

The topic with the greatest amount of visits is the one on "Systems." That was a surprise to the editorial team, who interpret it to mean that systems engineers are interested in the connection between systems science and systems engineering.

8. Conclusion

The SEBoK offers the student of systems engineering many opportunities for data mining. This article has shown some preliminary results that are interesting. They include the most heavily cited primary references, the areas of fewer references, the longitudinal distribution of references, the impact of various institutions on the literature of systems engineering, and the extent to which the community is favoring certain topics of the SEBoK.

Additional insights will be gathered as the SEBoK continues to be studied.

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